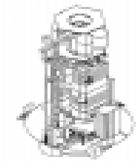
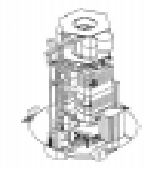


CHAMPOLLION/DS-4 MISSION OVERVIEW

The following is a subset of the slides presented at the CISM workshop on 6/3/97. Many of the slides showing details of the design, including graphics are not yet available in .ppt format.

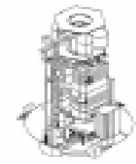
Brian Muirhead

Champollion Project Manager



MISSION OBJECTIVES

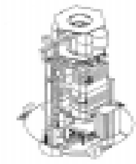
- **The Champollion Mission currently under study at JPL is designed to:**
  - **Perform the first landing of scientific instruments on the surface of a cometary nucleus**
  - **Demonstrate technologies for collecting and returning extra-terrestrial samples to a mother spacecraft, and/or directly to Earth.**
- **Mission rationale**
  - **Comets contain a cosmo-chemical record of the conditions and composition of the primordial solar nebula at the time of the formation of the planetary system.**
  - **The *in situ* study and return of cometary samples are thus among the highest priority goals of the planetary exploration program.**



CHAMPOLLION / DS-4

BACKGROUND

- **Champollion was proposed as a comet lander in late 1995 as a joint US/French development to fly on the European Rosetta mission (launch 2003)**
  - **US lead for lander development w/3 PI instruments**
  - **France lead for operations w/2 PI instruments**
- **US participation in lander withdrawn in fall, 1996**
  - **Lack of funding (i.e. funding profile), no relief on delivery schedule and need for hard commitment before President's '98 budget was known, main reasons for withdrawal**
  - **Agreed to look into providing support to US PI's on Rosetta orbiter and, if funding allowed, Co-I support**
- **Shortly after withdrawal, Elachi proposes joint Champollion/NMP**
  - **Complete mission concept developed and worked for rendezvous and sample return options**
- **Broad support within science communitee**
  - **NMP SWG has endorsed the mission concept including sample return**
  - **Solar System Exploration Subcommittee supports mission including sample return**
- **Wes Huntress has approved the marriage of Champollion and NMP. Will develop details, including technologies to be flown and will present back to HQ this summer.**

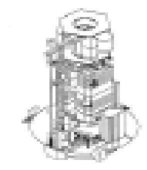


PROPOSED MISSION REQUIREMENTS AND EXPERIMENTS

- **Primary Requirements**
  - **Demonstrate the following technologies:**
    - » **Advanced solar array (CIS, inflatable deploy & stiffening, 100w/kg)**
    - » **Advanced SEP technology**
    - » **Integrated, high performance electronics**
    - » **Multi-function structures**
    - » **High specific energy primary and secondary batteries**
    - » **Precision guidance, landing and anchoring**
    - » **Subsurface sample acquisition and transfer to instruments**
    - » **Transfer to a sample return vehicle**
  - **Perform in-situ analysis of a comet**

- **Secondary Requirements**
  - **Autonomous rendezvous and docking**
  - **Sample return to earth surface**

- **Experiments**
  - **Optical based precision guidance and landing**
  - **Cryogenic maintenance of a sample thru Earth return**
  - **Remote agents for navigation and surface operations**



CHAMPOLLION / DS-4

Science Goals and Instruments

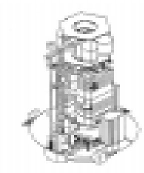
- **Large Scale Properties**
  - **Panoramic Surface Imaging, Internal Comet Structure**
- ***In Situ* Compositional Measurements**
  - **Elemental, Molecular, Mineralogical and Isotopic**
- **Physical Properties**
  - **Phases, Texture, Porosity, Density, Material Strength, Thermal and Dielectric Characteristics**
- **Nucleus mass, morphology, bulk density, structure**

Selected Lander Payload

PI/Organization	Name	Type
Yelle/Boston University (US)	**CIRCLE**	Near field camera, microscope, IR spectrometer
Bibring/IAS (France)	**ISIS**	Panoramic camera
D'Uston/CESR (France)	**CHAMPAGNE**	Gamma ray spectrometer
Mahaffy/GSFC (US)	**CHARGE**	Gas chromatograph/ mass spectrometer
Ahrens/CalTech (US)	**CPPP**	Physical properties probes

Total Science Mass: 18 kg
(includes sample acquisition/transport)

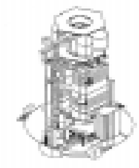
Note: Carrier camera and possible additional science is TBD. Continued French role is TBD but budget assumes US developed instrument(s) from Explor. Tech. line item.



CHAMPOLLION / DS-4

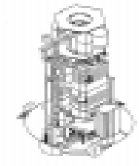
STATUS

- Since withdrawal from Rosetta mission, Champollion lander has been reconstituted as a standalone mission
  - Studied rendezvous and sample return options
  - Planning based around May/03 launch (March/02 option also attractive)
- Large uncertainties about the characteristics of comets make such a first mission inherently risky and a valuable precursor for any future mission
  - High technology approach being used to reduce risks associated with unknown topography and surface properties, including precision landing, anchoring
  - Anchor design and testing is key early demonstration and is underway
  - Simulant development program is producing materials for anchoring testing
- Architecture uses lander as smart stage w/”dumb” cruise stage (SEP & telecom)
  - Have detailed mechanical design, including electronic packaging and instrument accommodation.
  - Electrical design is evolving around best technology in concert w/ X-2000
- Cruise stage design is adequately mature, using solar electric propulsion configuration, X-band telecom relay to earth and high performance solar array.
- Sample return has various options for return including Stardust-like re-entry vehicle and a ballistic return trajectory using bi-prop (possible risk reducer).
- Working with NM IPDT’s to identify and agree on new technologies to be flown



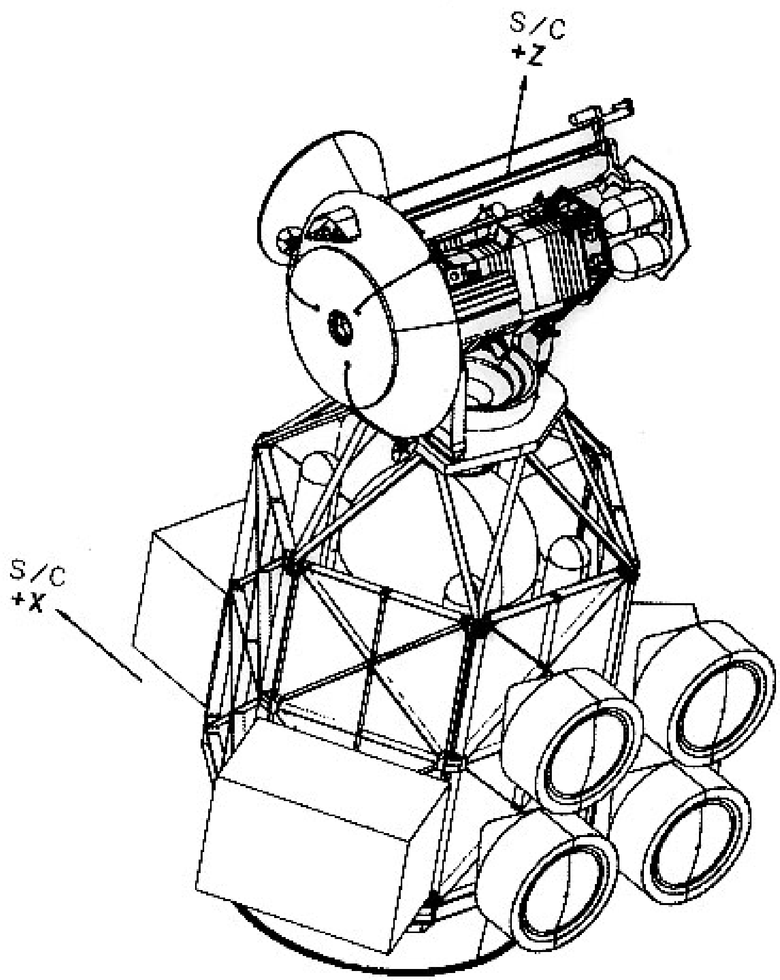
CRUISE MISSION

- **The current Champollion mission plan is to launch in April 2003 (various other options exist, earlier and later) on either a Delta 7925.**
- **A solar-electric propelled carrier spacecraft will carry the Champollion lander to a rendezvous with periodic Comet Tempel 1.**
- **Flight time with the SEP stage is 2.7 years, considerably shorter than typical ballistic trajectories.**
- **Rendezvous occurs post-perihelion at about 2.5 AU from the Sun.**
- **After a series of slow flybys, the spacecraft will be placed in a low orbit around the nucleus of Tempel 1.**
- **Champollion plans to spend 115 days at the comet in order to map completely the nucleus surface at high resolution, prior to deploying the lander spacecraft.**
- **Demonstrates technologies for:**
  - **Super small, low power, integrated avionics and S/W**
  - **Lightweight solar power using CIS (copper-indium-diselenide) technology and inflatables**
  - **Advanced SEP engines and feed system**
  - **Autonomous rendezvous, docking and operations**

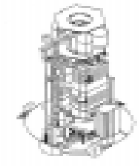


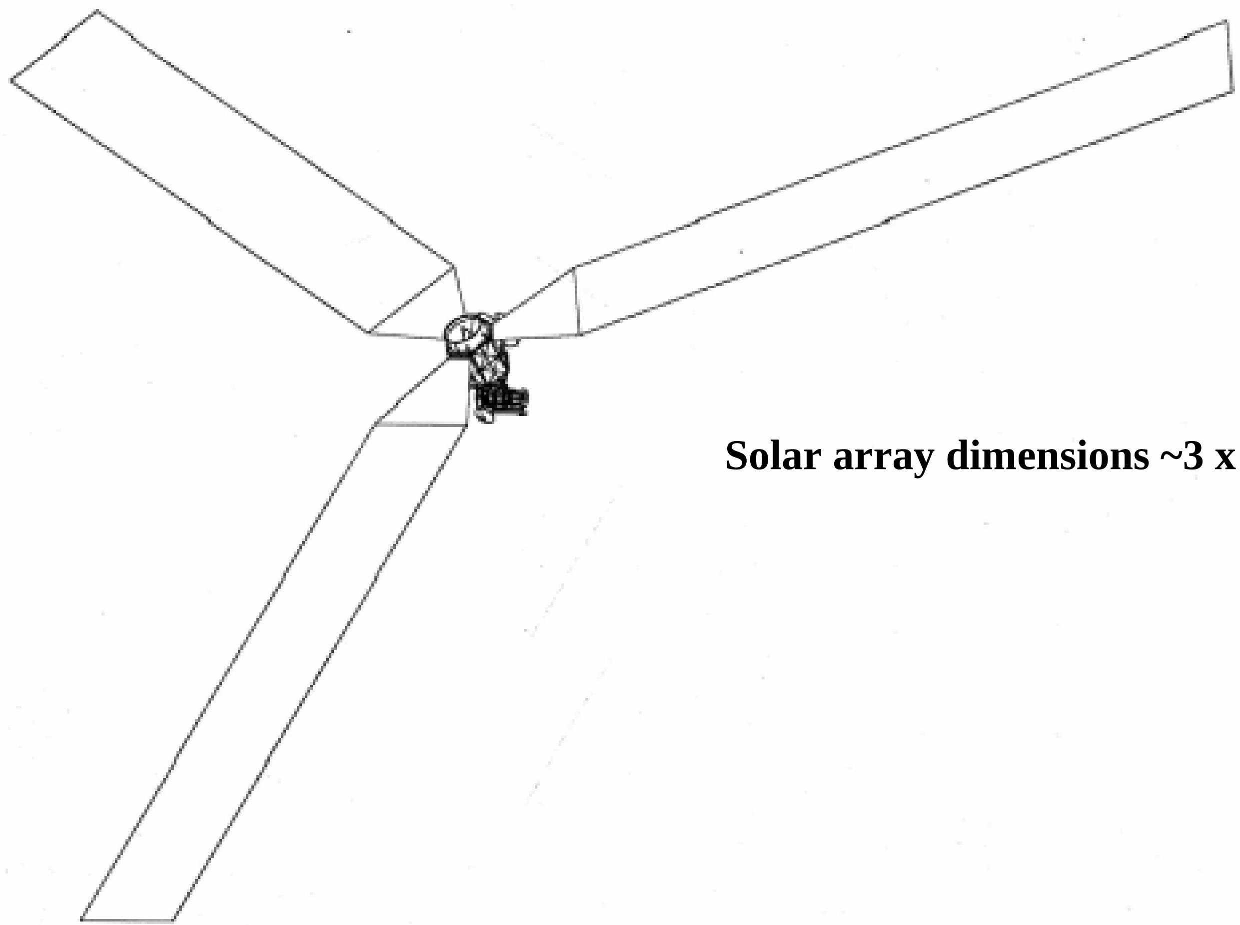
CHAMPOLLION / DS-4

LAUNCH CONFIGURATION

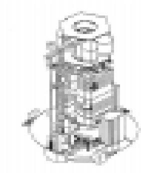


CRUISE CONFIGURATION



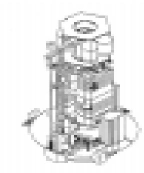


Solar array dimensions ~3 x 20m



LANDER MISSION

- The 3-axis stabilized Champollion lander will slowly descend to the surface using autonomous navigation, nulling out the lander velocity just before contact with the nucleus.
- At touchdown a harpoon-like anchor will attach the spacecraft to the surface to permit drilling operations and other scientific measurements.
- Science operations on the nucleus surface are expected to last 3 1/2 days.
- Scientists on the ground will update sequences based on quick-look analyses of earlier measurements.
- Demonstrates technologies for:
  - Precision guidance and landing, including sensors, algorithms & hazard avoidance
  - Anchoring
  - Sample acquisition, delivery to instruments, packaging and transfer
  - In-situ instruments
  - Primary batteries



SAMPLE RETURN

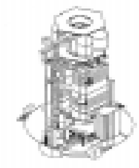
- **Having finished its in-situ measurements, the Champollion lander will then collect a sub-surface sample(s), detach itself from the anchor, take off, rendezvous with the carrier spacecraft, and transfer the sample to the carrier spacecraft.**
- **Depending on the launch vehicle used and the resources which NASA can allocate to the mission, the cometary sample may then either be analyzed onboard the carrier spacecraft or returned to Earth for analysis in terrestrial laboratories.**
- **Flight time back to Earth would be about 4.2 years, delivering the sample in May, 2010.**
- **The sample would be enclosed in a direct entry capsule, maintained at <150K if possible, that would decelerate in the Earth's atmosphere and then parachute to the surface.**
- **Demonstrates technologies for:**
  - **Automated operations**
  - **Sample transfer**
  - **Sample preservation and contamination control**
  - **Re-entry systems**

Working List of Needed Technologies

Technology Item	Requirement	Provider (Funds, H/W)	IPDT	Status
Precision guidance and landing algorithms, sensors	V_h<15cm/s, V_v<25cm/s	Core/On-board Auto/Mars Tech., JPL	Auto.	Small body & Mars activities. Coord. small body requirements
Landing, anchoring	Robust, low shock, stable platform	Champollion	MAMS	Work on-going, coord. cont.
Sample acquisition and transfer	Subsurface from 20 cm to 100 cm, low mass/pwr	Core/Planetary Robotic, JPL/Industry	MAMS	Work on-going, coord. cont.
Integrated micro electronics	Processor, memory, uplink, downlink, transponder, pwr	X-2000, JPL	N/A	Work on-going, coord. cont.
High specific energy primary batteries (e.g. LiSOCl2)	**400 w-hr/kg, >2A current**	**Core/Power, TBD**	**MAMS**	**No existing prog.**
Lightweight flexible solar array	>100w/kg	Philips Lab, LMA	MAMS	Work on-going, coord. cont.
Inflatable solar array deployment system	>20m deployed length, stiffness TBD	Core/Struc/Mat., JPL/LaRC/Industry	MAMS	Component/fundamental work in place, no system validation
Advanced SEP	2x lifetime, MEMS feed sys., pwr processor, redundancy	Core/Propulsion, LeRC/JPL	MAMS	Component work on-going, no system validation planned

Working List of Needed Technologies

Technology Item	Requirement	Provider (Funds, H/W)	IPDT	Status
Multifunctional structure	Integrated struc, elec., cable, prop.	Philips Lab, LMA	MAMS	Work on-going, coord. cont.
High specific energy secondary batteries (e.g. lithium ion)	>100 w-hr/kg	Core/Power, LeRC/JPL/industry	MAMS	Work on-going for low cycle applications
Single chip transceiver	Lander to cruise comm. @ <50 km, >90Kbps	Core/Comm., JPL	Comm	Developing for Mars, investigate small body applic.
Sample transfer and packaging for earth return	>10gm sample, hermetic seal, cryo maintenance <150K	Core/Mars Tech., JPL/Industry	MAMS	Work on-going, coord. with Mars Prog..
Autonomous docking	<10cm off., V_z <5cm/s, <5 deg. align, <5deg/sec tip-off	Core/On-board autonmony, JPL	Auto/ MAMS	Algorithm work on-going, No work in mechanical designs
Re-entry vehicle, thermal protection sys. & rapid recovery	Super lightweight, Earth entry, vel. TBD	Core & Expl. Tech., ARC/LaRC/JPL	N/A	Starting coord. w/ Mars prog. & Stardust
Active pixel sensor	1000x1000 detector	Core, JPL	N/A	Work on-going, coord. cont.



CHAMPOLLION / DS-4

PROGRAMMATIC APPROACH

- **Programmatic approach:**
  - **Build a team made up of Champollion, New Millennium and possibly CNES**
  - **Capitalize on developments by:**
    - » **X2000/CISM**
    - » **Exploration Tech.**
    - » **Others: S/C System Tech. Program, DOD….**
- **Key is to find mission and system design that satisfies the objectives of NMP technology mission and Champollion science mission and meets funding magnitude and phasing constraints**
- **Implementation mode: In-house w/ industry partner**
- **Near Term Milestones**

– **NMP SWG decision on DS-4 content**	**3/97**	**Approved**
– **Preliminary technology implementation plan**	**4/97**	**In Process**
– **Report to SSES**	**4/97**	**Done**
– **Mid-term report to HQ**	**4/97**	**Done**
– **Initiate detailed proposal for mission**	**4/97**	**In process**
– **Final confirmation of Rosetta payload by SPC**	**6/97**	
– **Formal mission proposal to HQ**	**9/97**	